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Specification and Drawings, as originally filed, with Application for Patent Serial No:  
2,409,883, on October 29, 2002, by GARY LEWIS, for "Extraction of Nitrogen Compounds  
from Combustion Exhaust Gases".

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**ABSTRACT**

A system is provided for extracting nitrogen compounds from combustion exhaust gases, which is particularly suited for use with an agricultural irrigation system. The system includes an exhaust chamber in communication with the motor driving the irrigation pump of the irrigation system for receiving the exhaust gases therethrough. Water is injected into the exhaust chamber for mixing with the exhaust so that the steam being formed absorbs various nitrogen compounds from the surrounding hot exhaust gases. The steam is subsequently condensed in a condensing chamber from which condensate is collected and dispensed into the inlet of the irrigation pump with the irrigation water. The irrigation water is thus enriched with various nitrogen compounds absorbed from the exhaust gases. A catalytic converter may be coupled in series with the exhaust chamber for extracting certain desirable nitrogen compounds in the condensate.

# **EXTRACTION OF NITROGEN COMPOUNDS FROM COMBUSTION EXHAUST GASES**

## **FIELD OF THE INVENTION**

The present invention relates to a method and system for extracting  
5 nitrogen compounds from combustion exhaust gases, and more particularly to a system for extracting nitrogen compounds from exhaust gases in an irrigation pump motor of an agricultural irrigation system for subsequent use of the nitrogen compounds in irrigation water of the irrigation system.

## **BACKGROUND**

10 Various nitrogen compounds are known to be desirable for fertilizing various plants, in particular crops. Continuously adding fertilizer to crops however can be time consuming and costly.

## **SUMMARY**

According to one aspect of the present invention there is provided a  
15 system for extracting nitrogen compounds from exhaust gases of a combustion device, the system comprising:

an exhaust chamber having an inlet and an outlet for receiving the exhaust gases from the combustion device therethrough;

20 a water injector for injecting water into the exhaust chamber for mixing with the exhaust gases to form water vapor;

a condensing chamber for condensing the water vapor exiting the exhaust chamber with the exhaust gases; and

a collector for collecting condensate from the condensing chamber.

25 The use of an exhaust chamber in combination with a water injector permits nitrogen to be readily collected from exhaust gases of commonly available combustion device, including internal combustion engines and the like, at minimal

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cost and effort as the nitrogen compounds available in the exhaust gases are normally considered useless and therefore wasted. Collection of nitrogen compounds in a condensate is particularly useful in an agricultural irrigation system as compounds are ready for immediate use with little or no effort on the part of the operator of the irrigation system. Further benefits to injecting water into the exhaust chamber for mixing with the irrigation water include preheating the irrigation water with heat from the exhaust gases and reducing undesirable emissions in the exhaust gases due to the mixing of the gases with water vapor in the exhaust chamber.

There may be provided a catalytic converter coupled to an inlet of the exhaust chamber for receiving the exhaust gases therethrough prior to the exhaust chamber.

The water injector is preferably arranged to inject water into the exhaust chamber in response to a level of condensate in the condensing chamber falling below a prescribed level of condensate. The water injector in this instance may include a float valve coupled in series therewith, the float valve being supported in the condensing chamber to control injection of water in response to condensate level.

When there is provided an inlet pipe coupled to the inlet of the exhaust chamber which includes a downwardly extending portion at the exhaust chamber, the water injector is preferably supported to inject water into the inlet pipe at the downwardly extending portion.

The condensing chamber may include a condenser core having cooling fluid circulating therethrough.

In some embodiments, the system may comprise a retrofit kit for connection to an existing motor of an irrigation pump of an agricultural irrigation system and wherein the collector is arranged to be coupled to an inlet of the

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irrigation pump.

According to a second aspect of the present invention there is provided a system for extracting nitrogen compounds from combustion exhaust gases, the system comprising:

- 5 a combustion device for producing exhaust gases;
- an exhaust chamber in communication with the combustion device for receiving the exhaust gases from the combustion device therethrough;
- a water injector for injecting water into the exhaust chamber for mixing with the exhaust gases;
- 10 a condensing chamber for condensing water vapor exiting the exhaust chamber with the exhaust gases; and
- a collector for collecting condensate from the condensing chamber.

The combustion device preferably comprises an internal combustion engine, however other combustion devices, for example turbine engines and the like, may be used satisfactorily.

The collector is preferably coupled to communicate with an inlet of an irrigation pump for dispensing the condensate into irrigation water passing through the irrigation pump. The combustion device in this instance preferably comprises the motor driving the irrigation pump.

20 There may be provided a shut-off valve coupled in series between the collector and the irrigation pump which is arranged to be open only when the irrigation pump is operating.

When the condensing chamber includes a condenser core, the core may include passages through which irrigation water is circulated for cooling.

25 The water injector may be coupled to an outlet of the irrigation pump whereby the water injected into the exhaust chamber comprises a portion of the

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water pumped by the irrigation pump. In this configuration, the system may be used for preheating irrigation water by exchanging heat with the exhaust gases in the exhaust chamber to recover waste heat from the exhaust gases.

According to a further aspect of the present invention there is provided  
5 a method for extracting nitrogen compounds from exhaust gases of a combustion device, the method comprising:

operating a combustion device to produce exhaust gases;

directing the exhaust gases through an exhaust chamber in  
communication with the combustion device;

10 injecting water into the exhaust chamber for mixing with the exhaust gases;

condensing water vapor exiting the exhaust chamber with the exhaust gases; and

collecting condensate from the condensing chamber.

15 When the combustion device comprises a motor of an irrigation pump of an agricultural irrigation system, the method preferably includes dispensing condensate from the condensing chamber into irrigation water being pumped through the irrigation pump.

The step of injecting water into the exhaust chamber may comprise  
20 directing a portion of the irrigation water being pumped through the irrigation pump into the exhaust chamber.

The method may also include passing the exhaust gases through a catalytic converter prior to the exhaust chamber.

#### BRIEF DESCRIPTION OF THE DRAWINGS

25 In the accompanying drawings, which illustrate an exemplary embodiment of the present invention:

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Figure 1 is a schematic view of the extraction system for extraction of nitrogen compounds to be used in an irrigation system.

Figure 2 is a flow chart diagram illustrating the method in which nitrogen is extracted from combustion gases in an irrigation system.

## 5 DETAILED DESCRIPTION

Referring to the accompanying drawings, there is illustrated a nitrogen compound extraction system generally indicated by reference numeral 10. The phrase "nitrogen compounds" is understood in this specification to include any nitrogen related compounds including nitrous oxide ( $N_2O$ ), nitrite ( $NO_2$ ), nitrate ( $NO_3$ ), ammonium ( $NH_4$ ) and other aqueous or non-aqueous compounds containing nitrogen which may be known to have benefits for fertilizing plants.

The extraction system 10 is particularly useful in combination with or as a retrofit kit for conversion of an agricultural irrigation system 12. The irrigation system 12 generally includes an irrigation pump 14 for pumping water from a source 16 of irrigation water to a crop or plants to be irrigated. The pump is driven by a pump motor 18 which typically comprises an internal combustion engine consuming commonly available fossil fuels, for example gasoline, natural gas, propane or diesel fuel and the like.

The irrigation pump 14 includes an inlet 20 and an outlet 22. The inlet is coupled to a suction line 24 in communication with the water source 16 while the outlet communicates with an irrigation pressure line 26 which directs the irrigation water to an area to be irrigated.

The extraction system 10 includes an exhaust chamber 28 which is similar in construction to a conventional automotive muffler. The exhaust chamber is a sealed chamber having an inlet opening 30 at a top end and an outlet opening 32 at a bottom end thereof. An inlet pipe 34 connects the inlet at the top of the exhaust

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chamber 28 in communication with the exhaust of the motor 18 of the irrigation system. The inlet pipe 34 includes a downwardly extending portion 36 which extends downwardly into the exhaust chamber 28 after an elbow 38 redirecting the inlet pipe from the motor. The exhaust chamber further includes internal baffles 40  
5 which redirect the exhaust passing therethrough from the inlet pipe 34 to an outlet pipe 42 which is axially misaligned with the inlet pipe. As in a conventional automotive muffler the exhaust must pass through various baffles 40 and possibly through perforations in the respective inlet and outlet pipes in order to navigate through the exhaust chamber.

10 A catalytic converter 44 is coupled in series with the inlet pipe between the motor 18 and the exhaust chamber 28 so that exhaust gases pass through the catalytic converter prior to entering the exhaust chamber. The catalytic converter acts as a catalyst for the hot exhaust gases from the motor to react some of the compounds within the exhaust gases. The catalytic converter may be removed  
15 depending upon the desirable nitrogen compounds which are to be extracted and depending upon the particular application, the type of motor 18 and the type of fuel being consumed.

A water injector 46 is provided for injecting water into the hot exhaust gases as it enters the exhaust chamber 28. The water injector is coupled to the  
20 downwardly extending portion 36 of the inlet pipe to prevent backflow of injected water to the motor 18 of the pump. The water is sprayed into the exhaust chamber for mixing with the hot exhaust gases to be converted to steam before exiting through the outlet pipe. The water injector 46 receives water from the irrigation pressure line 26 to which it is coupled so as to receive pressurized irrigation water  
25 from the pump outlet to be injected into the exhaust chamber by an injector line 64.

The outlet pipe of the exhaust chamber 28 feeds into a condensing



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chamber 48 where the mixture of water vapor or steam and hot exhaust gases form condensate in the form of water enriched with nitrogen compounds. The condensing chamber 48 generally comprises a forty-five gallon barrel or drum having an inlet pipe 50 extending downwardly into the barrel at a top end thereof to which the outlet pipe of the exhaust chamber is coupled. The condensing chamber further includes an exhaust opening 52 at the top end thereof. A condenser core 54 is provided within the condensing chamber which spans the walls of the chamber between the open end of the inlet pipe 50 and the exhaust opening 52. The condenser core includes passages therethrough for circulating a cooling fluid to assist in the condensation process. In the illustrated embodiment the cooling fluid comprises water which is circulated from the irrigation pressure line 26.

A collector line 56 couples to a drain 58 at a bottom end of the condensing chamber. The collector line 56 is coupled at an opposite end to the suction line 24 adjacent the inlet of the pump 14 so that condensate collected from the condensing chamber by the collector line 56 is drawn into the inlet of the pump with the irrigation water from the source 16 to be subsequently distributed by the irrigation pressure line to the area to be irrigated.

A shut-off valve 60 is coupled in series with the collector line 56 between the condensing chamber 48 and the suction line 24 to selectively interrupt flow of condensate through the collector line. The shut-off valve 60 includes a suitable controller for opening the valve 60 only when the pump motor 18 is operating so that the shut-off valve 60 is closed when the motor is not in operation to prevent leakage of condensate into the suction line.

A float valve 62 is supported within the condensing chamber 48 and is coupled in series with the injector line 64 coupling the water injector to the irrigation pressure line. The float valve is arranged to be opened only when a level of

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condensate within the condensing chamber falls below a prescribed level so that in the instance when the level falls below the prescribed level, the water injector 46 injects water to raise the condensate level. Once sufficient condensate collects within the condenser above the prescribed level, the float valve 62 closes to prevent further water being injected into the exhaust chamber. The float valve 62 ensures that condensate level remains above the drain 58 and corresponding collector line 56 to prevent air from being drawn into the suction line of the pump.

In operation, the irrigation system is first started by operating the irrigation pump 14 using the pump motor 18. The motor draws in intake air from the surrounding air which is approximately 78% nitrogen in the form  $N_2$ . The high heat of combustion in combination with the compression and spark ignition of the engine converts the nitrogen to useable forms of nitrogen compounds, for example nitrous oxide. The hot exhaust gases exit the motor and pass into the exhaust chamber 28 at which point the water injector 46 sprays water into the hot stream of exhaust gases entering downwardly into the exhaust chamber to form steam in the exhaust chamber which absorbs and collects nitrogen compounds from the hot exhaust gases forming various nitrogen compounds in aqueous solution with the water vapor. The condensate which then forms in the condensing chamber 48 includes such compounds as  $NO_2$ ,  $NO_3$ , and  $NH_4$ . As noted above the water level within the condensing chamber is controlled by the float valve to inject water from the irrigation pressure line as required to maintain condensate level above the prescribed level. As long as the motor of the irrigation pump remains in operation, the shut-off valve 60 remains open so that condensate from the condensing chamber is sucked through the collector line 56 into the suction line 24 of the irrigation pump to subsequently fertilize an area to be irrigated with nitrogen compounds carried by irrigation water. By passing the exhaust through the additional catalytic converter

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before entering the exhaust chamber, the type or quantity of desirable nitrogen compounds can be increased in the condensate which later forms as different types of exhaust gases are converted as required depending upon the type of combustion device and the type of fuel being combusted.

5 Further benefits of the use of water injected into an exhaust chamber as described above include the pre-heating of irrigation water and control of emission gases from the combustion device. The addition of water to the exhaust gases is beneficial to the environment because the interaction of water with the hot exhaust gases causes some undesirable emissions to be converted to less harmful  
10 compounds that are less damaging to the environment and because the system requires no additional energy consumption other than the use of equipment which would otherwise already be in operation.

When the water injected into the exhaust chamber comprises irrigation water which is returned to the irrigation pump, the exhaust chamber acts as a heat  
15 exchanger to recover waste heat from the exhaust gases to preheat the irrigation water. Preheating the irrigation water is of benefit so that cold source water, for example from a river, provides less thermal shock to irrigated plants which would normally be warmer than the source water.

While one embodiment of the present invention has been described in  
20 the foregoing, it is to be understood that other embodiments are possible within the scope of the invention. The invention is to be considered limited solely by the scope of the appended claims.

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## CLAIMS:

1. A system for extracting nitrogen compounds from exhaust gases of a combustion device, the system comprising:

an exhaust chamber having an inlet and an outlet for receiving the exhaust gases from the combustion device therethrough;

a water injector for injecting water into the exhaust chamber for mixing with the exhaust gases to form water vapor;

a condensing chamber for condensing the water vapor exiting the exhaust chamber with the exhaust gases; and

a collector for collecting condensate from the condensing chamber.

2. The system according to Claim 1 wherein there is provided a catalytic converter coupled to an inlet of the exhaust chamber for receiving the exhaust gases therethrough prior to the exhaust chamber.

3. The system according to Claim 1 wherein the water injector is arranged to inject water into the exhaust chamber in response to a level of condensate in the condensing chamber falling below a prescribed level of condensate.

4. The system according to Claim 1 wherein the water injector includes a float valve coupled in series therewith, the float valve being supported in the condensing chamber such that the water injector is arranged to inject water into the exhaust chamber in response to a level of condensate in the condensing chamber falling below a prescribed level of condensate.

5. The system according to Claim 1 wherein there is provided an inlet pipe coupled to the inlet of the exhaust chamber which includes a downwardly extending portion at the exhaust chamber, the water injector being supported to inject water into the inlet pipe at the downwardly extending portion.

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6. The system according to Claim 1 wherein the condensing chamber includes a condenser core having cooling fluid circulating therethrough.

7. The system according to Claim 1 wherein the system comprises a retrofit kit for connection to an existing motor of an irrigation pump of an agricultural irrigation system and wherein the collector is arranged to be coupled to an inlet of the irrigation pump.

8. A system for extracting nitrogen compounds from combustion exhaust gases, the system comprising:

a combustion device for producing exhaust gases;

10 an exhaust chamber in communication with the combustion device for receiving the exhaust gases from the combustion device therethrough;

a water injector for injecting water into the exhaust chamber for mixing with the exhaust gases;

15 a condensing chamber for condensing water vapor exiting the exhaust chamber with the exhaust gases; and

a collector for collecting condensate from the condensing chamber.

9. The system according to Claim 8 wherein the combustion device comprises an internal combustion engine.

20 10. The system according to Claim 8 wherein the collector is coupled to communicate with an inlet of an irrigation pump for dispensing the condensate into irrigation water passing through the irrigation pump.

11. The system according to Claim 10 wherein the combustion device comprises a motor driving the irrigation pump.

25 12. The system according to Claim 10 wherein there is provided a shut-off valve coupled in series between the collector and the irrigation pump, which is arranged to be open only when the irrigation pump is operating.

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13. The system according to Claim 10 wherein the condensing chamber includes a condenser core which is cooled by irrigation water passing therethrough.

5 14. The system according to Claim 10 wherein there is provided a catalytic converter coupled in series between the combustion device and the exhaust chamber for receiving the exhaust gases therethrough.

10 15. The system according to Claim 10 wherein the water injector is arranged to inject water into the exhaust chamber in response to a level of condensate in the condensing chamber falling below a prescribed level of condensate corresponding to an inlet of the collector.

16. The system according to Claim 10 wherein the water injector is coupled to an outlet of the irrigation pump whereby the water injected into the exhaust chamber comprises a portion of the water pumped by the irrigation pump.

15 17. A method for extracting nitrogen compounds from exhaust gases of a combustion device, the method comprising:

operating a combustion device to produce exhaust gases;

directing the exhaust gases through an exhaust chamber in communication with the combustion device;

20 injecting water into the exhaust chamber for mixing with the exhaust gases;

condensing water vapor exiting the exhaust chamber with the exhaust gases; and

collecting condensate from the condensing chamber.

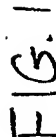
25 18. The method according to Claim 17 wherein the combustion device comprises a motor of an irrigation pump of an agricultural irrigation system and wherein the method includes dispensing condensate from the condensing

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chamber into irrigation water being pumped through the irrigation pump.

19. The method according to Claim 18 wherein injecting water into the exhaust chamber comprises directing a portion of the irrigation water being pumped through the irrigation pump into the exhaust chamber.

5 20. The method according to Claim 17 including passing the exhaust gases through a catalytic converter prior to the exhaust chamber.



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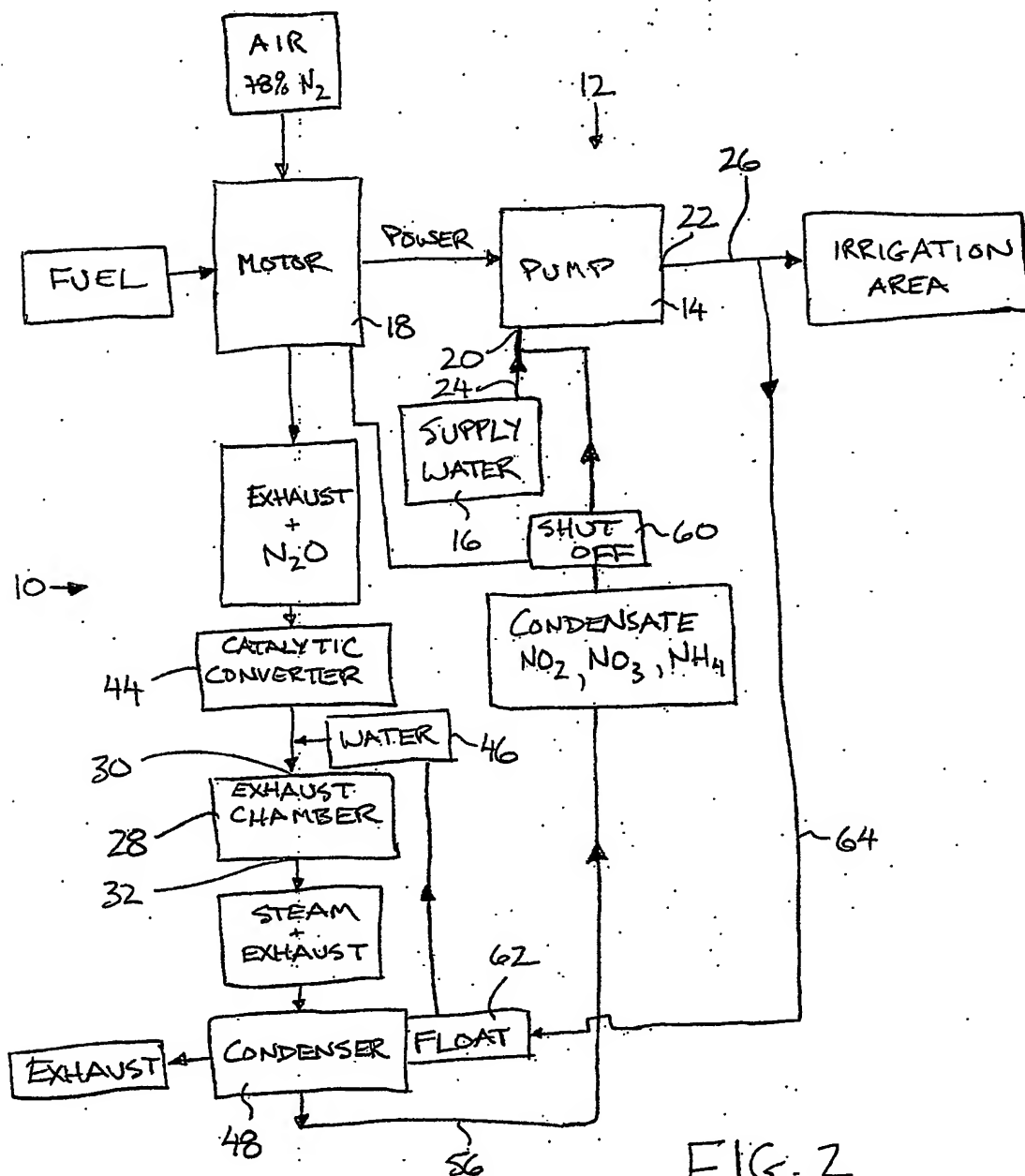


FIG. 2

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